EP155 MIDTERM EXAM
Feb. 6, 2002

student name _____ student No. _____

TIME: 1.5 HOURS

One 8.5X11 sheet of paper and calculator allowed

Constants

$$k = 9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$$

charge on an electron $= -1.602 \times 10^{-19}$ C

resistivity of copper at 20°C $= 1.723 \times 10^{-8}\ \Omega \cdot \text{m}$

resistivity of aluminum at 20°C $= 2.825 \times 10^{-8}\ \Omega \cdot \text{m}$

inferred absolute zero temperature for copper $= -234.5$°C

inferred absolute zero temperature for aluminum $= -236$°C

inferred absolute zero temperature for Nickel $= -147$°C

Q1 _____

Q2 _____

Q3 _____

Q4 _____

Q5 _____

Q6 _____

Total _____

(8)

1. Figure 1 shows the location of two positively charged particles. The particle denoted Q_1 contains 0.29253 nC of charge and the particle denoted Q_2 contains 0.201 nC of charge. The two particles have x,y coordinates 6,1 and 6,11 respectively, where each coordinate has units centimeters.

   It is pointed out that the dotted semicircle with a radius of 5 cm and center at Q_2 is not a equal-potential line. This semicircle is needed to answer one of the questions below.

   NOTE: FIGURE 1 is not drawn to scale.

   (a) Find the total force on a test charge, say Q_t, of 2×10^{-2} C when it is at point A (point A has x,y coordinates 6,6).

   (b) How much work is done by the charge (as opposed to the work required by an applied force) if it is moved from point A to point B (point B has x,y coordinates 11,1).

   (c) What is the electric potential of +1 C of charge at point B w.r.t. point A (i.e. what is V_{BA}).

   (d) *** Clearly indicate on the graph in Figure 1 the point on the semicircle of radius 5cm and center at Q_2 where the electric potential w.r.t. point A is -20 V.

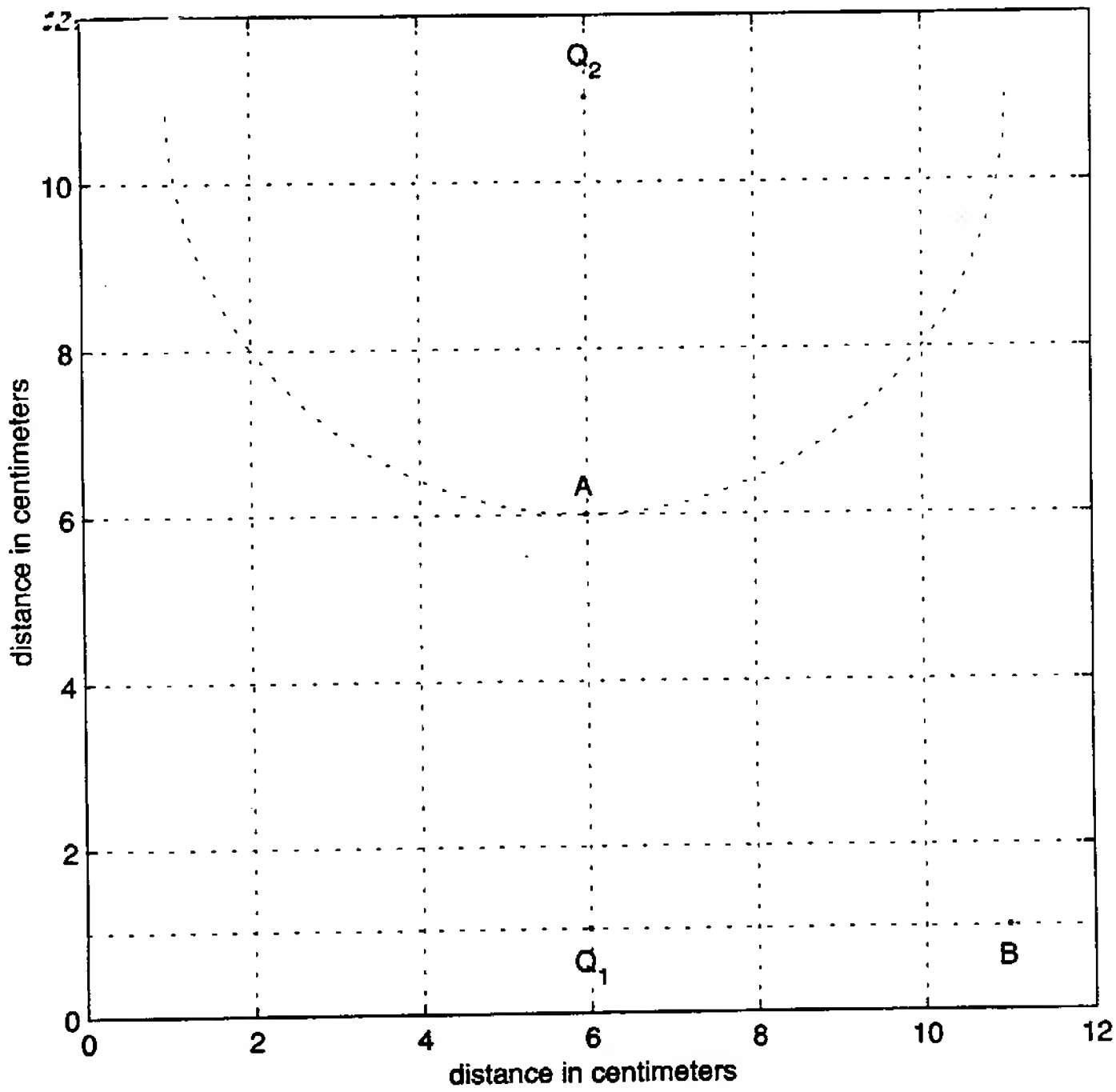

Figure 1

(8)

2. Figure 2 shows equal-potential contours in an electric field created by three charged particles labeled Q_1, Q_2, and Q_3. The map is not drawn to scale but has distance marked on the x and y axes.

   (a) The equal-potential contours are 1 volt apart. The potential at point A with respect to point D is positive. What is the electric potential of +1 C of charge at point B w.r.t. point F?

   (b) What is the force in the horizontal direction on +5 mC placed at point D? A positive answer means the direction of the force is to the right.

   (c) Some test charge of unknown amount and sign is placed at B. This charge experiences a total force of 100 N in a direction away from particle Q_2. What is the force on this charge in the vertical direction? If the direction is up then the answer will have a positive sign.

   (d) The amount of charge on all three particles is changed and possibly charge of the opposite sign is used. The charge on all three particles is changed in proportion so that the equal-potential lines follow the curves in the map of Figure 2. However, the size of the voltage step per line changes and quite possible, the sign of the voltage step changes as well.

   With the new charge on the particles, the force on a test charge of +2 mC placed at point B is 0.5 N in the direction away from Q_2. What is the voltage V_{AB}? You need the correct sign for the answer to be correct.

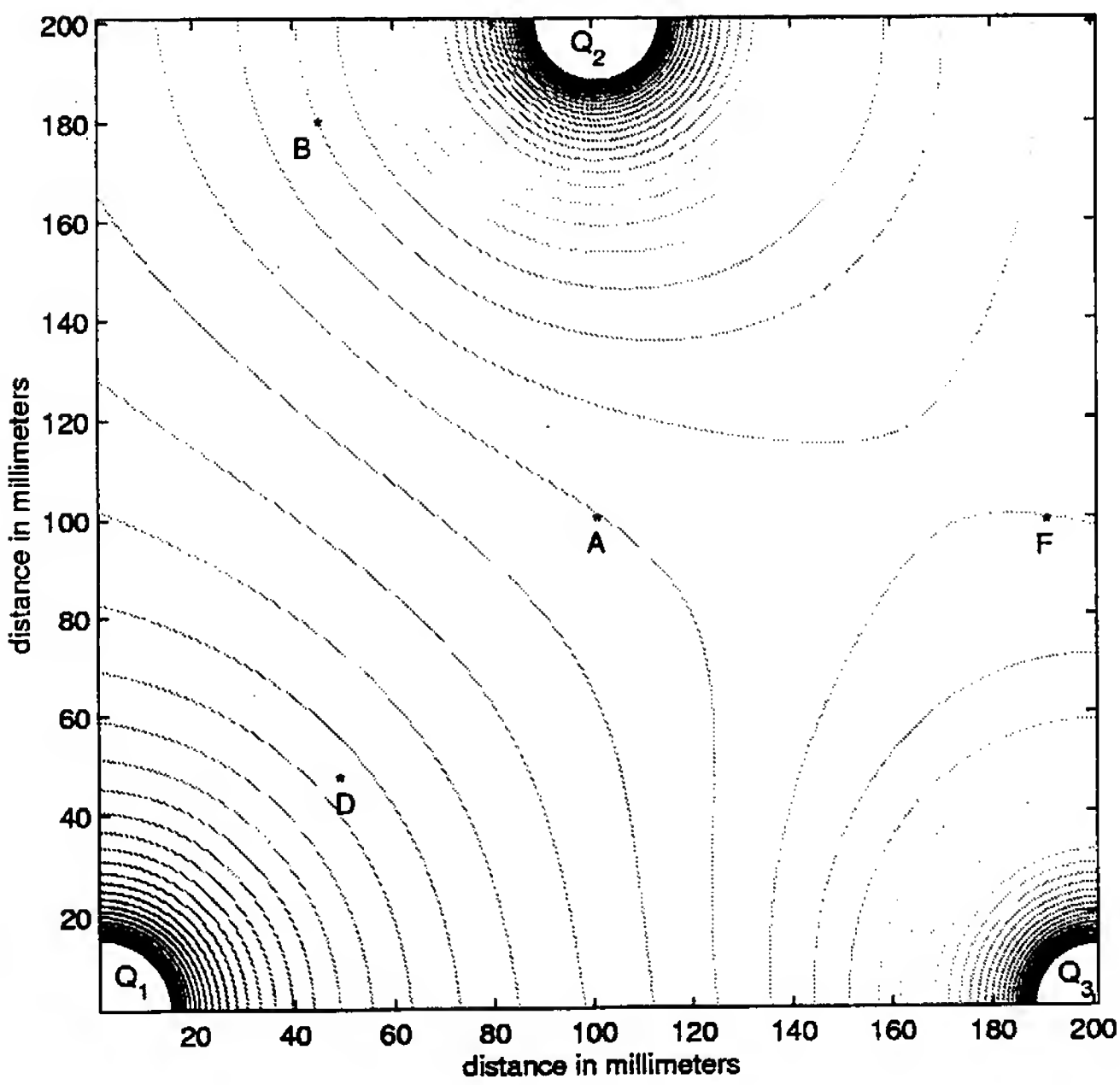

Figure 2:

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(6)

3. An aluminum wire 1000 m long has a resistance of 7 ohms. A copper wire of the same length and cross section area is connected in series(i.e. the total length of the connected wires is 2000 m). Both wires are at a temperature of 20 degrees centigrade.

   (a) What is the total resistance of total length of wire (i.e. the full 2000 m)?

   (b) What is the resistance of the 1000 m long aluminum wire if the wire temperature is changed to $-40°C$?

   (c) *** What is the temperature coefficient at $20°C$ of the dual composition resistor comprised of the two 1000 m lengths of aluminum and copper wires?

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(6) 4. Three resistors are made from nickel wire wound around spools. The resistors are denoted R_1, R_2, R_3. The wire used in all resistors has the same cross sectional area. However, the length of the wire used in R_2 is twice that of R_1 and the length of the wire used in R_3 is three times that of R_1.

(a) The three resistors are connected in series and a voltage of 1 V is applied across the. This voltages causes a current of 0.1667 amperes to flow through the resistors. What is the resistance of resistor R_1.

(b) At what rate does resistor R_1 convert electrical energy to heat?

(c) The current measurement was made with the resistors at a temperature of 0°C, what would the current read if the temperature of the resistors were changed to 100°C.

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(6)

5. A series circuit is shown in Figure 3. The current flowing in the circuit is 10 mA. The value of all elements except resistor R_1 are known and as indicated in the Figure.

   (a) What is V_{AB}? The sign of your answer must be correct to get full credit for this question.

   (b) At what rate is energy converted from chemical energy to electrical energy by the 9 V battery. The sign of your answer must be correct to get full credit for this question.

   (c) What is the value of R_1.

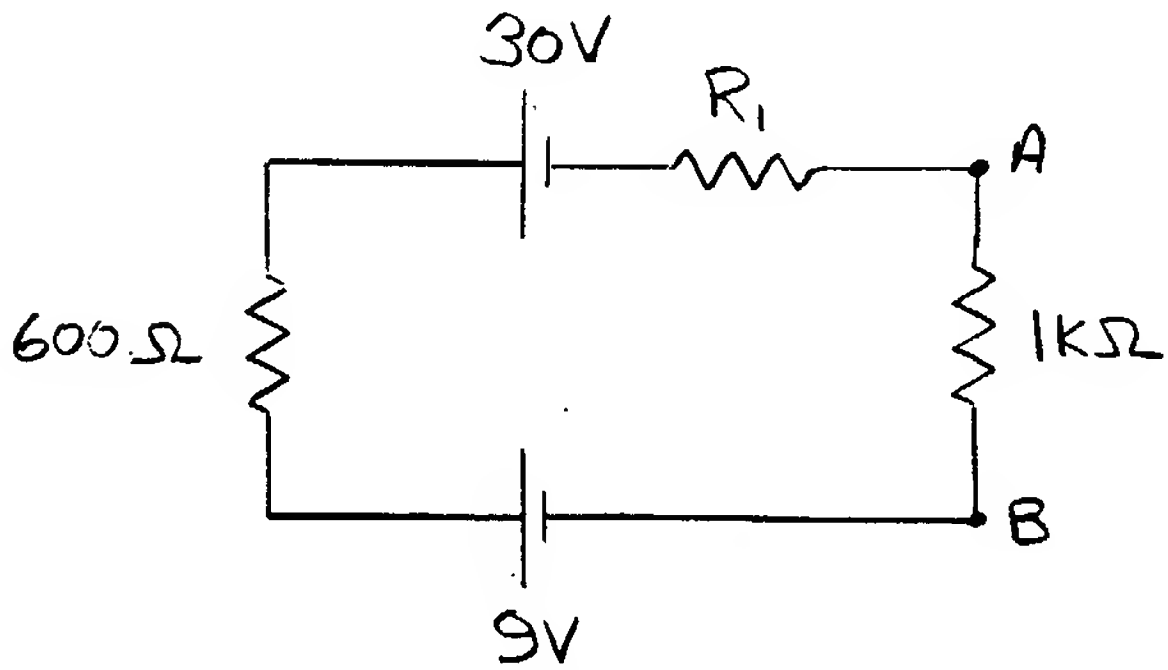

Figure 3

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(6) 6. A series circuit is shown in Figure 4. The power dissipated by resistors R_1, R_2 and R_3 are 0.1 W, 0.3 W and 0.5 W respectively.

(a) At what rate does the 12 V battery convert chemical energy to electrical energy? The sign of your answer must be correct to get full credit for this question.

(b) What is the value of resistor R_1?

(c) What is V_A?

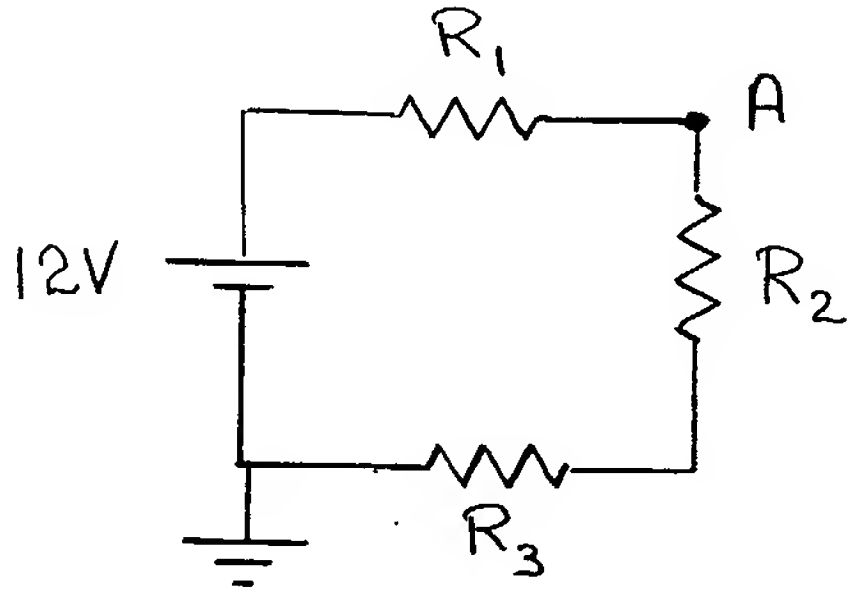

Figure 4

THE END